



BIG BANG TO BIOSIGNATURES: THE LUVOIR MISSION CONCEPT

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LUVOIR study scientist

Science with the HST and JWST Telescopes 5

Venice Italy

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What is LUVOIR ?

Crab Nebula with HST ACS/WFC
Credit: NASA / ESA

Large UV / Optical / Infrared Surveyor (LUVOIR)

A space telescope concept in tradition of Hubble

- Broad science capabilities
- Far-UV to Near-IR bandpass
- ~ 8 – 16 m aperture diameter
- Suite of imagers and spectrographs
- Serviceable and upgradable

“Space Observatory for the 21st Century”

Decades of science

Ability to answer questions we have not yet conceived

Imagine astronomy without Hubble ...



Hubble Ultra Deep Field
(ultra-deep imaging)



Imagine astronomy with LUVOIR ...

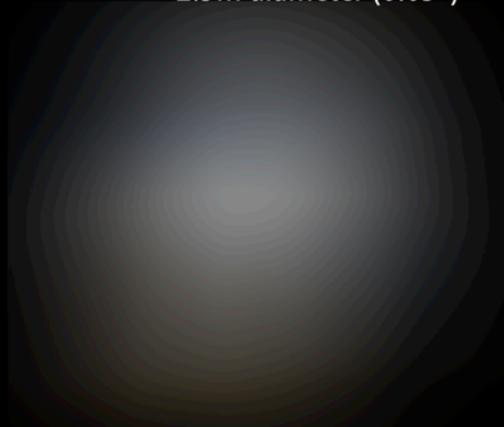
Hypothetical planet "Nine"

Located at ~1000 AU
Diameter of 40,000 km



Hubble Space Telescope (HST)

Best optical resolution (2016)
2.5m diameter (0.05")



LUVOIR

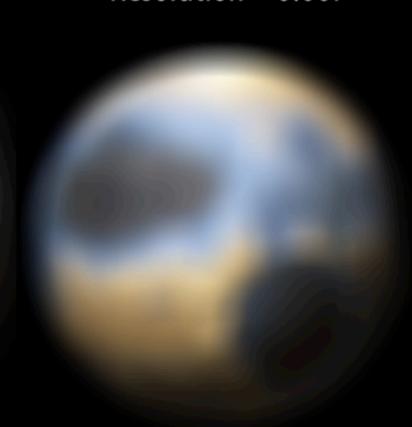
6m diameter
Resolution ~0.02"



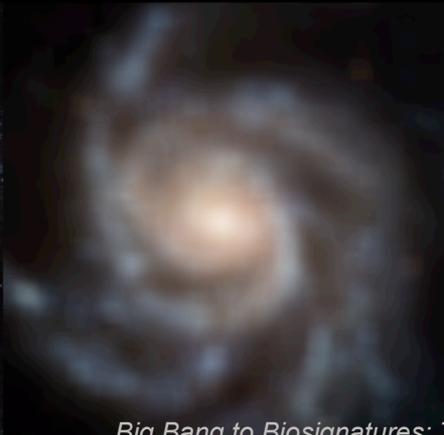
*Clear Identification of
local differences*

LUVOIR

18m diameter
Resolution ~0.007"



*Detailed mapping of the
surface morphologies and
composition anisotropies*



How we're doing the study

NASA started four large mission concept studies in Jan 2016 to prepare for Astro2020 Decadal Survey

- LUVOIR
- Habitable Exoplanet Imaging Mission (HabEx)
- Origins Space Telescope (aka. Far-IR Surveyor)
- X-Ray Surveyor

Two LUVOIR mission architectures to be studied

- Aperture sizes chosen Nov 2016: 15-m and ~ 9-m

Study office and engineering team at GSFC

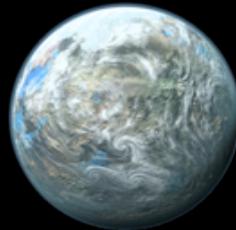
How we're doing the study

Science and Technology Definition Team

- 24 voting members from community
- 8 non-voting reps. of international space agencies

Six Community Working Groups

- Exoplanets
- Cosmic Origins
- Solar System
- Simulations
- Communications
- Technology



Four Instrument Teams

STDT voting members



Debra Fischer
(Yale)



Brad Peterson
(Ohio State / STScI)



Jacob Bean
(Chicago)



Daniela Calzetti
(U Mass)



Rebekah Dawson
(Penn State)



Courtney Dressing
(Caltech)



Lee Feinberg
(NASA GSFC)



Kevin France
(Colorado)



Olivier Guyon
(Arizona)



Walter Harris
(Arizona / LPL)



Mark Marley
(NASA Ames)



Leonidas Moustakas
(JPL)



John O'Meara
(St. Michael's)



Vikki Meadows
(Washington)



Ilaria Pascucci
(Arizona)



Marc Postman
(STScI)



Laurent Pueyo
(STScI)



David Redding
(JPL)



Jane Rigby
(NASA GSFC)



Aki Roberge
(NASA GSFC)



David Schiminovich
(Columbia)



Britney Schmidt
(Georgia Tech)



Karl Stapelfeldt
(JPL)



Jason Tumlinson
(STScI)

The LUVOIR instruments

Observational challenge

Faint planets next to bright stars

Solution

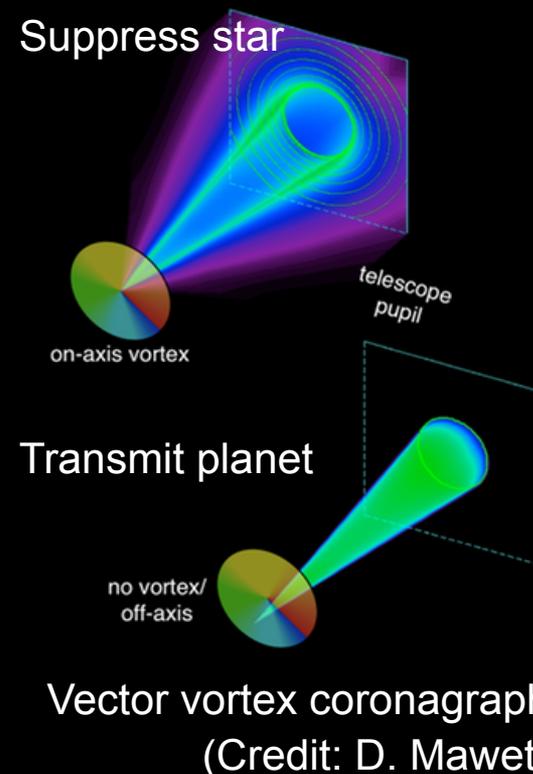
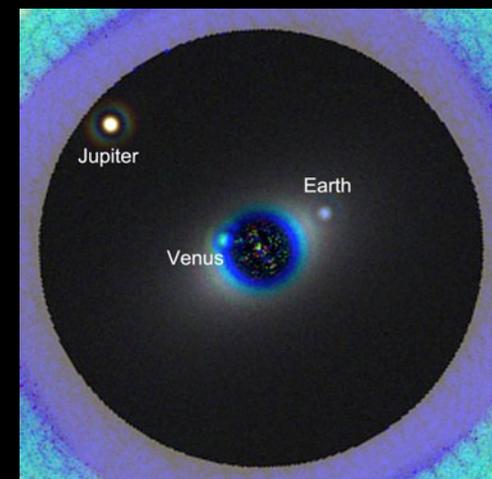
Optical / Near-IR Coronagraph

Contrast $< 10^{-10}$ to observe exoEarths

Low resolution spectroscopy ($R > 150$)

Bandpass: $0.2 \mu\text{m}$ to $2.4 \mu\text{m}$

Tech development via WFIRST
coronagraph



The LUVOIR instruments

Observational challenge

No UV through Earth's atmosphere

Solution

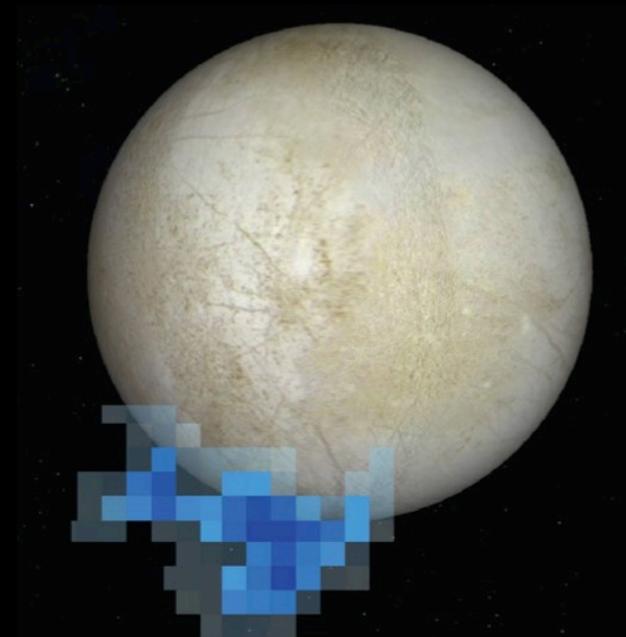
LUMOS

Far-UV to near-UV spectroscopy

Multi-object capability

Near-UV imaging

Major upgrade of HST STIS



HST STIS UV instrument

The LUVOIR instruments

Observational challenge

Imaging deep fields at high resolution

Solution

High-Definition Imager

2 x 3 arcmin field-of-view

Optical to near-IR bandpass

High precision astrometry mode

Major upgrade of HST WFC3



HST Wide Field Camera 3

The LUV0IR instruments

Observational challenge

Measuring warm molecules present in Earth's atmosphere

Solution

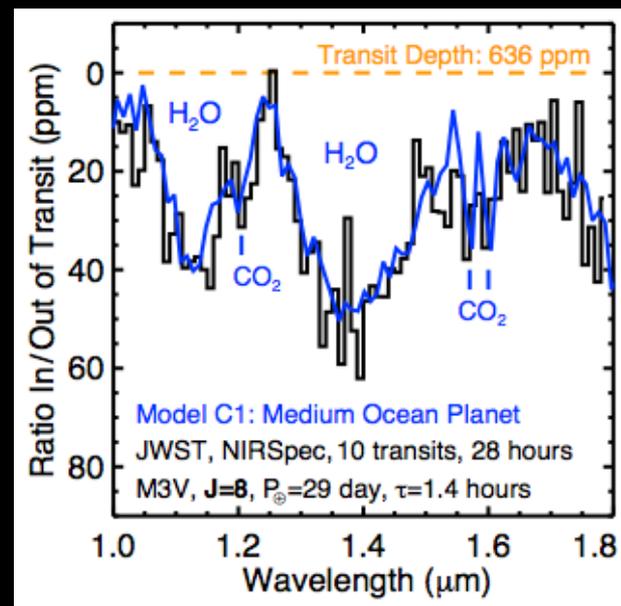
Optical / Near-IR Spectrograph

Multiple resolutions up to $R \sim 10^5$

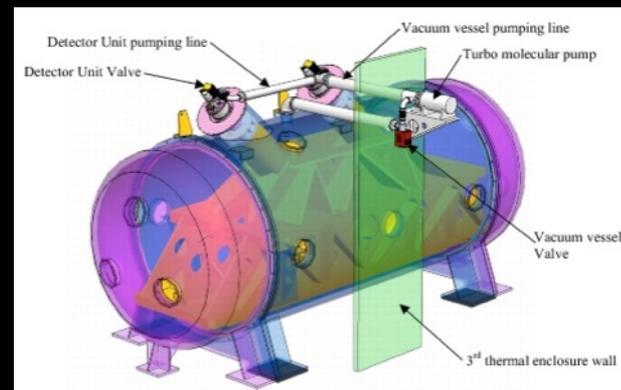
High photometric precision for transits

Possibly high precision RV to measure planet masses

Ground-based analogs in development



Credit: Natasha Batalha



ESPRESSO spectrograph for VLT (Credit: ESO)

POLLUX: a European contribution to the LUVOIR mission study

- ▶ POLLUX is a concept for a UV spectro-polarimeter with high resolution point-source capability ($R \sim 10^5$)
- ▶ Complimentary to the LUMOS instrument
- ▶ To be defined & designed by a consortium of 10 European institutions, with leadership/support from CNES
 - ▶ Instrument leads: Coralie Neiner & Jean-Claude Bouret
- ▶ The conceptual study conducted by CNES could serve as a support for a future ESA contribution

LUVOIR online simulation tools in development

<http://asd.gsfc.nasa.gov/luvoir/tools/>

Large UV/Optical/Infrared Surveyor (LUVOIR)

 National Aeronautics and Space Administration
Goddard Space Flight Center

Astrophysics Science Division • Sciences and Exploration



LUVOIR

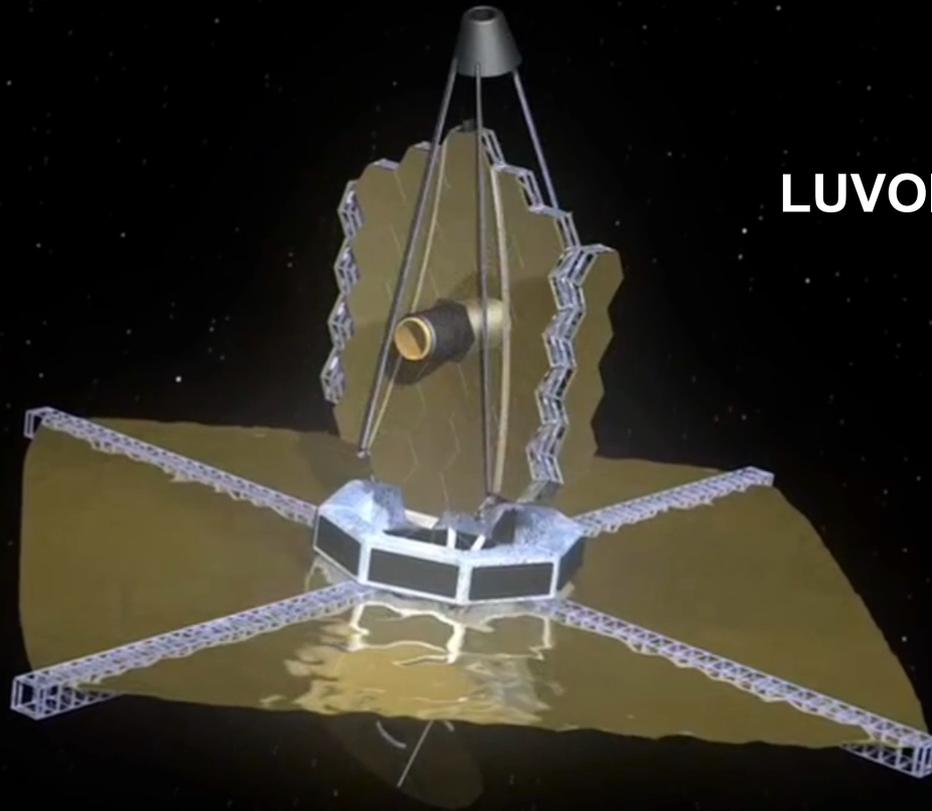
Large UV/Optical/Infrared Surveyor

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|--|---|---|---|--|---|---|--|--|--|
| Home | <h3>On-Line Simulation Tools</h3> <p>This page links to performance simulation and visualization tools for the LUVOIR mission, a future ultraviolet / optical / near-infrared observatory concept.</p> <p>These widgets are experimental. If they are not working, email Jason Tumlinson (STScI). For the Planetary Spectrum Generator, email Geronimo Villanueva (GSFC).</p> <table border="1"><tr><td>HDI Photometric ETC Basic exposure time calculator for optical photometry in multi-band images.</td><td>Coronagraphic Spectra of Exoplanets Simulate optical/near-IR reflection spectra of various exoplanets with realistic noise.</td></tr><tr><td>LUMOS Spectroscopic ETC Simple exposure time calculator for UV spectroscopy.</td><td>Multiplanet Yield Tool Tool for visualizing yields of observed exoplanets (of various types) as function of basic mission parameters.</td></tr><tr><td>UV MOS Visualizer See the impact of UV multi-object spectroscopy on the study of stellar clusters and their feedback.</td><td>Planetary Spectrum Generator Advanced tool for simulating spectra of Solar System bodies (with LUVOIR and other telescopes).</td></tr><tr><td>High-Resolution Imaging Examples of astronomical objects viewed with different sized telescopes.</td><td></td></tr></table> | HDI Photometric ETC Basic exposure time calculator for optical photometry in multi-band images. | Coronagraphic Spectra of Exoplanets Simulate optical/near-IR reflection spectra of various exoplanets with realistic noise. | LUMOS Spectroscopic ETC Simple exposure time calculator for UV spectroscopy. | Multiplanet Yield Tool Tool for visualizing yields of observed exoplanets (of various types) as function of basic mission parameters. | UV MOS Visualizer See the impact of UV multi-object spectroscopy on the study of stellar clusters and their feedback. | Planetary Spectrum Generator Advanced tool for simulating spectra of Solar System bodies (with LUVOIR and other telescopes). | High-Resolution Imaging Examples of astronomical objects viewed with different sized telescopes. | |
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Technological challenges

Deployment of large segmented telescope

To be demonstrated by JWST



LUVOIR deployment

Technological challenges

Need heavy lift launch vehicle with large fairing

Suitable vehicles (SLS and commercial) in development

Compatibility of UV and coronagraphy

New lab work shows UV reflective mirrors are just fine for coronagraphy

Ultra-high contrast observations with a segmented telescope

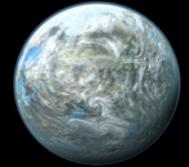
Coronagraphs can be designed for segmented telescopes.
Working hard to demonstrate needed system stability

Series of short, readable “LUVOIR Tech Notes” available at
<http://asd.gsfc.nasa.gov/luvoir/tech/>

Difference between LUVOIR and HabEx ?

Both LUVOIR and HabEx have two primary science goals

- Habitable exoplanets & biosignatures
- Broad range of general astrophysics



The two architectures will be driven by difference in focus

- For LUVOIR, both goals are on equal footing. LUVOIR will be a general purpose “great observatory”, a successor to HST and JWST in the $\sim 8 - 16$ m class
- HabEx will be optimized for exoplanet imaging, but also enable a range of general astrophysics. It is a more focused mission in the $\sim 4 - 8$ m class

Similar exoplanet goals, differing in quantitative levels of ambition

- HabEx will *explore* the nearest stars to “search for” signs of habitability & biosignatures via direct detection of reflected light
- LUVOIR will *survey* more stars to “constrain the frequency” of habitability & biosignatures and produce a statistically meaningful sample of exoEarths

The two studies will provide a continuum of options for a range of futures

Get involved with LUVOIR

<http://asd.gsfc.nasa.gov/luvoir/>

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NASA National Aeronautics and Space Administration
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LUVOIR

Large UV/Optical/Infrared Surveyor

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Large UV/Optical/Infrared Surveyor

The Large UV/Optical/IR Surveyor (LUVOIR) is a concept for a highly capable, multi-wavelength observatory with ambitious science goals. This mission would enable a great leap forward in a broad range of astrophysics, from the epoch of reionization, through galaxy formation and evolution, to star and planet formation. LUVOIR also has the major goal of characterizing a wide range of exoplanets, including those that might be habitable - or even inhabited.

LUVOIR is one of four Decadal Survey Mission Concept Studies initiated in Jan 2016. The study will extend over three years and will be executed by the Goddard Space Flight Center, under the leadership of a Science and Technology Definition Team (STDT) drawn from the community.

A brief description of LUVOIR science goals, wavelength coverage and sensitivity are available in this [flyer](#).

News

Third LUVOIR STDT Meeting

The third face-to-face team meeting took place in New Haven CT on Nov 9 & 10, 2016. The LUVOIR and HabEx teams met jointly on Nov 10. Meeting info can be found on the [Events](#) page.



4th meeting Apr 17 – 18,
2017 at JPL

Observers welcome at
all LUVOIR meetings &
telecons

Interim Report: Dec 2017
Final Report: Jan 2019